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NEW ASPECTS OF THERMOELASTIC CONTACT(U) MICHIGAN UNIV  
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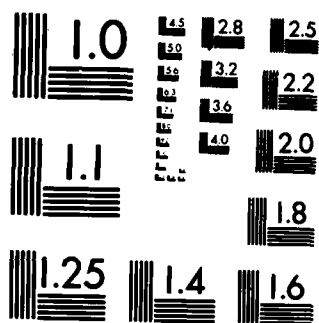
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NEW ASPECTS OF THERMOELASTIC CONTACT

FINAL REPORT

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October 18, 1984

U. S. ARMY RESEARCH OFFICE

CONTRACT NUMBER DAAG29-82-K-0001

THE UNIVERSITY OF MICHIGAN

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## BRIEF OUTLINE OF RESEARCH FINDINGS

This project has been concerned with a variety of problems in contact and fracture where the configuration of the system - and hence the correct formulation of the problem - is influenced by thermoelastic distortion. The results have been reported in refereed journal articles and will only be briefly summarised here.

### The Interface Crack with Heat Flow

Three papers [1,2,3] are concerned with the influence of thermoelastic distortion on heat conduction across a partly bonded interface between dissimilar materials. In all cases, it is found that a contact region is established in the unbonded region of the interface, but the extent of this region and the stress intensity factor are profoundly influenced by the direction of heat flow and by the algebraic sign of two composite material constants.

For both directions of heat flow, there is a range of conditions for which the steady-state solution is non-unique [2,3]. In this range, the configuration realised in practice will depend on the history of the thermal process, but if conditions are changed slowly through the multiple solution domain, there are conditions under which a transition will be forced from one solution branch to another, involving high transient thermal

stresses.

These results are applicable to the thermal failure of bimaterial interfaces such as a ceramic cutting tool tip bonded to a steel shank.

The solution of the above problems necessitated an extension [4] of the powerful techniques developed by Green and Collins for mixed boundary value problems.

#### Non-uniqueness and Stability

Further insight into the conditions leading to multiple steady-state solutions and their stability was obtained from an investigation of heat conduction through a duplex heat exchanger tube [5]. This example - which has practical applications in the power generation field - is the first published example of non-uniqueness in a system involving contact of similar materials. An extension of this work [6] shows that non-uniqueness can also occur in a counterflow heat exchanger under more general conditions than those defined by a local analysis of the problem.

The related problem of existence with over-idealised boundary conditions was pursued by treating the Hertz contact problem with heat flow, using the more realistic boundary condition of a pressure dependent thermal contact resistance [7]. The results

tend to confirm the validity of an earlier idealisation of this boundary condition using the concept of 'imperfect' thermal contact - a concept which is also used and discussed in [3].

### Frictionally-excited Thermoelastic Instabilities

An important class of thermoelastic contact problems is that in which the heat generated due to sliding friction produces thermoelastic distortion, which tends to localise the contact in a small region of the interface. This process places serious restrictions on the performance of aircraft brakes and is the subject of a renewal proposal currently under consideration by ARD.

Under the present project, a Green's function has been obtained for plane problems involving the steady motion of a heat source over a half-plane [8]. This solution is exact and is expressed in terms of easily computable Bessel functions. It has been applied to determine the influence of thermoelastic distortion on the pressure distribution under a sliding rigid punch [9].

Also, further investigations have been made into the transient process by which this condition is developed [10]. It is found that, if the initial contact area is large, it will first split up into several separate regions, one of which will then grow at the expense of the others until it carries all the

load. Maximum temperatures predicted by this analysis are in some cases substantially lower than those obtained by earlier more approximate methods.

#### Other

A general result has also been established, relating the thermally induced curvature of a finite cylinder to the local heat flux across its end faces [11]. This is of direct application in assessing the influence of thermal strain on the contact of two finite cylinders - a geometry commonly used for the measurement of thermal contact resistance.

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